

## QUALITY AND PRODUCTIVITY ANALYSIS IN A VERY SMALL ENTERPRISE USING TSPI

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**Abstract:** *This article shows the benefits of developing a software project using TSPI in a "Very Small Enterprise" based in quality and productivity measures. An adapted process from the current process based on the TSPI was defined and the team was trained in it. The pilot project had schedule and budget constraints. The workaround began by gathering historical data from previous projects in order to get a measurement repository, and then the project metrics were collected. Finally, the process, product and quality improvements were verified.*

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### Introduction

Large, medium and small enterprises have common problems related to the management and quality [IPRC, 2006] of software projects. This generates cost overruns, low quality and cancelled projects [Standish Group, 2007].

Some process models like the CMMI are not affordable for the small organizations [IPRC, 2006].

Organizations have recognized that the control of their software processes affects the success of their projects, *"they know what to do but not how to apply it"* [Noopur, 2003]. A new research line based on process improvement in small enterprises is arising in order to facilitate competitive capabilities for this environment in a global market [Glazer, 2006]. These are named Small Settings and include small and medium organizations, and small software projects [Garcia 2006]. (*This paper focuses on small organizations only*).

Team Software Process (TSP) is a framework that provides a customizable process based in an excellent experience in planning and managing software projects [Humphrey, 2006]. It guides teams in managing cost, schedule and quality [Noopur, 2003].

This article shows the quality and productivity results of using an adapted process based on the introduction of the Team Software Process (TSPI) in a very small enterprise. The following goals have been established (see Table 1):

Table 1 – Project goals

Number	Goal
1	To reduce the estimation deviation.
2	To verify the productivity improvement.
3	To verify the process and quality improvement.

The organization decided to use TSPI in order to accomplish the previous goals assuming the risk of modifying its current process. In order to verify the project goals, measures were evaluated comparing the pilot project and Historical average data.

Therefore, the organization decided to apply the basic TSPI principles, getting a customized process as a result of combining TSPI with the organizational process. A basic training was provided for the new process, and historical data were collected in order to facilitate the estimation of the pilot project.

In the following section, the article shows the organization, the development context and the pilot project attributes. Later, the historical data collection will be described, the new process will be analyzed and the advantages pointed out. The project goals will be verified using the project measures and the measurement repository, and finally, the conclusions will be described.

The schema showed in Figure 1 resumes the factors considered in the project.

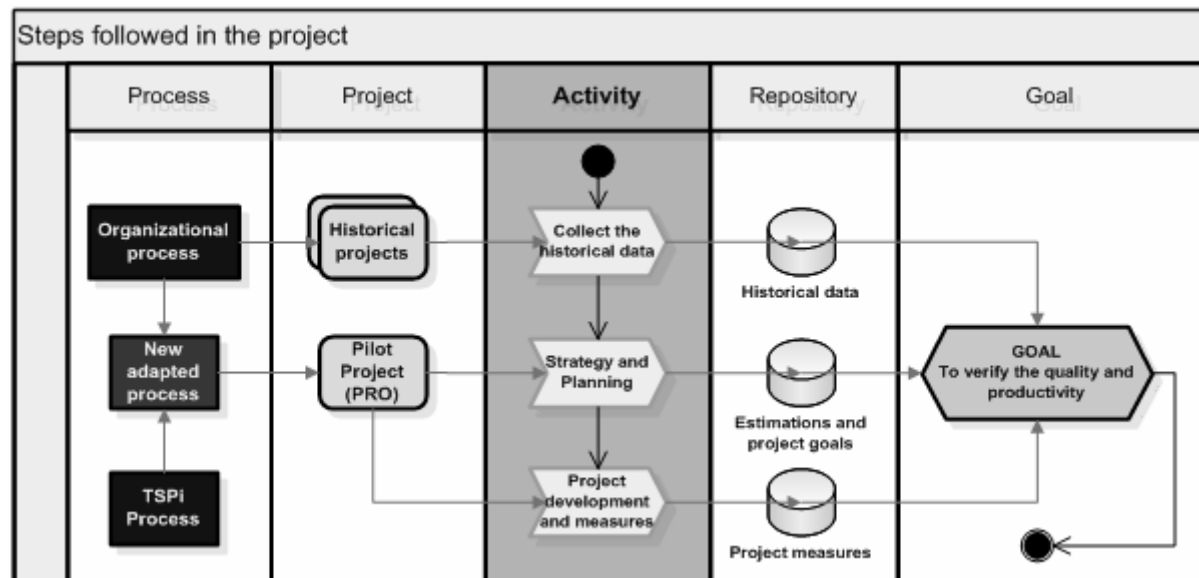


Figure 1 – Factors considered in the project

### Context: The organization and the pilot project

UPTA is a Spanish intersectorial organization who takes care of all the scopes of economic activity which they are exerted by self – employment. UPTA leads a lot of projects which generally need a specific software development and in the last year, the number of software projects has increased.

The working scenario has changed to a new environment where many projects were developed simultaneously, and with a greater number of involved people. As a result of an internal assessment, senior management detected that projects were delayed, dedicating additional efforts to accomplish the objectives. Moreover, products quality had decreased.

UPTA was interested in introducing a process model such as CMMI-DEV, but it could not afford for it.

Besides this handicap, UPTA had a project (called PRO) with schedule and budget constraints, and was delayed. The organization selected this project as the pilot.

### Collecting the historical data

Data on previous UPTA projects were not enough. There were only schedule and budget data, but in order to verify the project goals, defects and phases efforts data were needed.

Measures related to schedule, size, effort and defects were collected. In addition, some derived metrics were calculated in order to analyze the project results.

In order to support the analysis, historical projects were divided into three phases (see Table 2):

Table 2 – Project phases

Phase	Description
Development	From launch project until unit tests.
Test	It includes integration and system tests.
Operation	From the deployment until three months up.

Effort and defect data of these phases are approximated values because there was no previous data repository.

### The new process

The process is a customized process as a result of blending the basic TSPi principles and the previous organizational process. Once the new process was defined, the project started with a training on the new process and the launching meeting.

The TSPi phases were used in the new process in order to get benefits from its procedures and metrics, but the intermediate products, such as requirements or design specifications, were based on the previous organizational process in order to reduce the change impact.

The focus on quality is the main difference with the previous organizational process. Examples of this approach are the quality plan relative to the phases and process performance, inspections and reviews.

The team was empowered to estimate and plan the project balancing the workload, and so, they were more committed. Also, a role definition was adopted.

Table 3 shows the basic TSPi principles applied in the new process and the difference with the previous process.

Table 3 –TSPi principles applied in the new process

New process	Previous process
Process well defined. It makes easier the estimation and monitoring project	Process with inconsistencies. The phases are not well defined
Team motivated, participative and collaborative	Only a project leader elaborates the project plan and the task assignment
Quality focus based in an early defect detection and reduction	Since the schedules are restricted, the quality was not considered
Introduction of inspection activities in the process	Only personal reviews without a quality control
Detailed plan in order to avoid schedule and effort deviation	Projects begin with cost and schedule pre-established and restricted
Monitoring and project visibility with the earned value method	There is no mechanism to monitor the project status
Weekly meeting to analyse the project and to resolve process issues	There are no formal meetings and they are preformed only when there are problems

With respect to project management, weekly meetings and the earned value method were introduced. These gave to the project an actual visibility and an effective monitoring. The schedule, goals, risks, and change requests were evaluated in the weekly meetings.

The weekly meetings and the earned value method allowed the improvement of the project management [Humphrey, 1995] (see Figure 2).

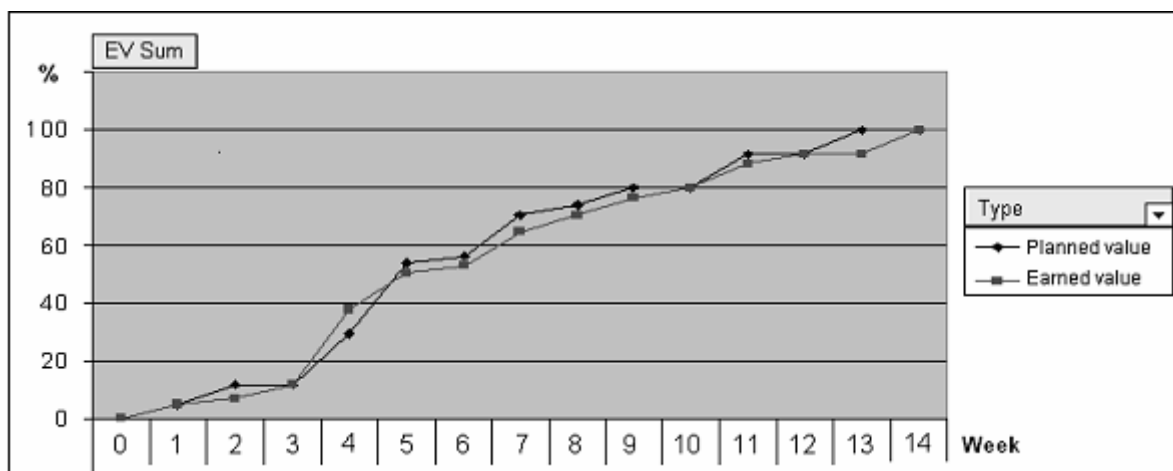


Figure 2 – Earned value monitoring

### Verifying the project goals

In order to verify the project goals, measures were evaluated comparing the PRO and the historical average data. The formula applied for the reduction is:  $\% \text{ Reduction} = (\text{Historical} - \text{PRO}) / \text{Historical} * 100\%$

Goal 1: To reduce the estimation deviation.

The estimation deviation related to schedule, size and effort were reduced (see Table 4).

Table 4 – Goal 1 results

Goal	Historical	PRO	Reduction
% Schedule deviation	21.4%	7.7%	64.0%
% Effort deviation	55.9%	18.00%	67.8%
% Size deviation	33.7%	22.6%	33.0%

Figure 3 shows graphically the improvement and demonstrates the utility of the new process in the organization.

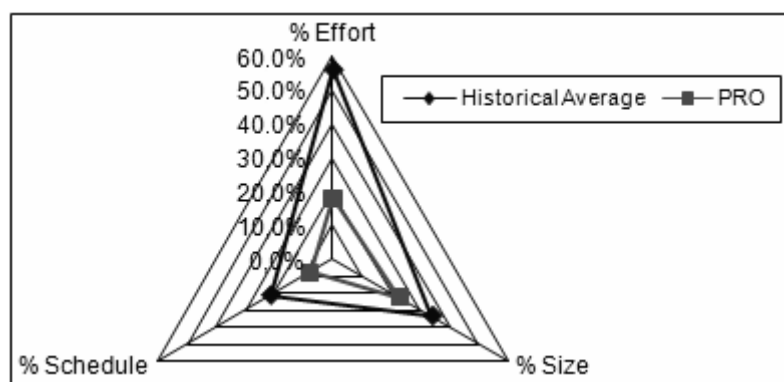


Figure 3 – Estimation deviation

**Goal 2: To verify the productivity improvement**

The released defect density ( $\rho$ ), the test productivity and the process productivity were analyzed in order to verify the productivity improvement.

Table 5 – Goal 2 results

Goal	Historical	PRO	Reduction
$\rho$ Released defects [def./KLOC]	2.0	1.2	40.9%
Test Productivity [hour/KLOC]	33.4	13.2	60.5%
Process Productivity [LOC/Hour]	7.3	7.6	- 3.9%

According to Table 5, the test productivity has been increased due to the defect reduction applied before the test phase through formal reviews and inspections. However, the process productivity has not been altered because the test effort was substituted by the quality activities balancing the total effort (process productivity was calculated using the LOC number coded by hour).

The released defects density has improved, but it is far from the TSPi indicators. Figure 4 shows the relationship between  $\rho$  Released defects and the product size.

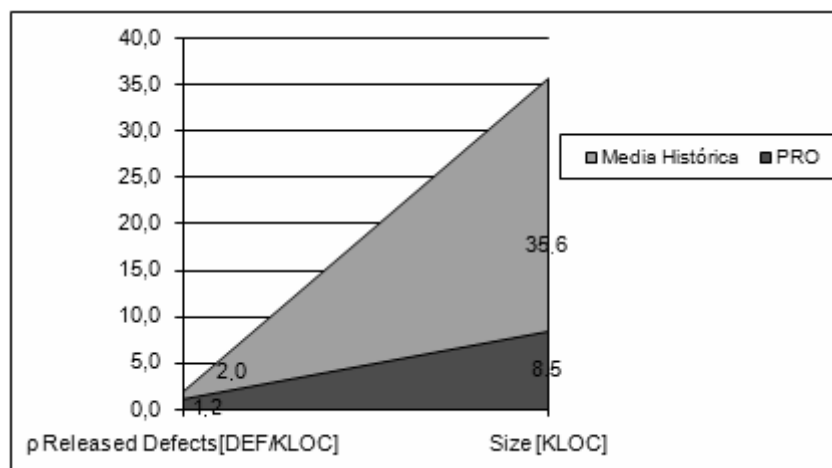


Figure 4 – Released defect density vs. Size

Figure 5 shows graphically the productivity improvement and confirms the benefits of the new adapted process.

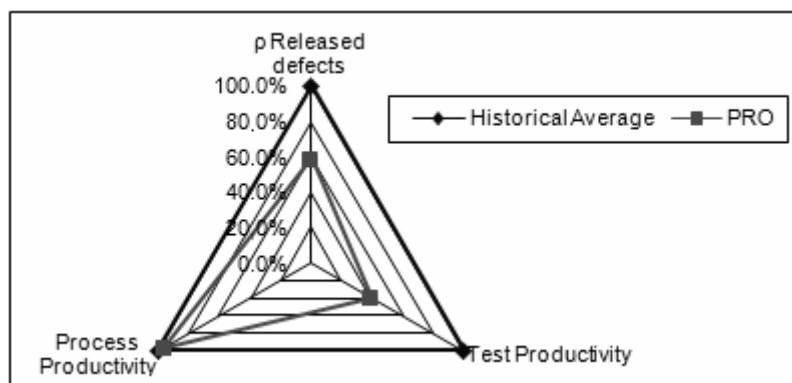


Figure 5 – Productivity improvement

### Goal 3: To verify the process and quality improvement

TSPi uses the defect density and process yield indicators in order to verify this goal.

The defect density allows analyzing the process. The process is considered effective when every phase has less or equal defect density than the last one [Humphrey, 1999]. Figure 6 shows that the new adapted process based in TSPi is more effective than the last one because the defect density was reduced in every project phase.

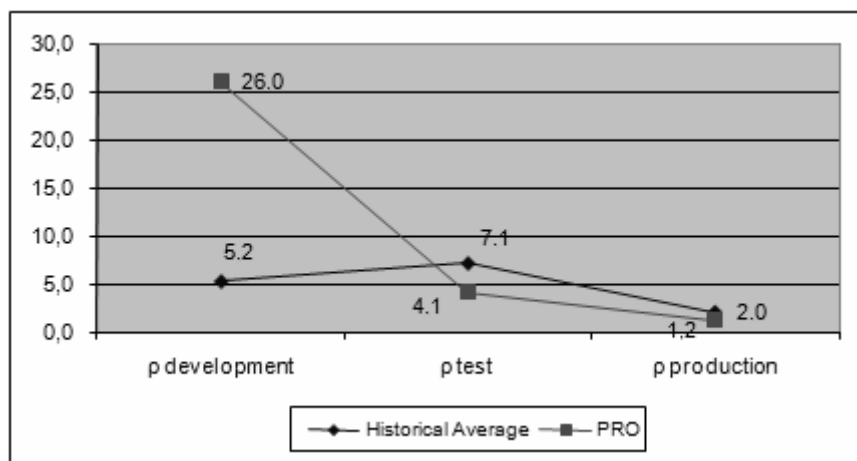


Figure 6 – Process improvement based in defect density

The process yield is a measure that allows analyzing the quality, which measures the percentage of removed defects before a given phase. Process yield goal with TSPi is to remove 99% of all defects before the test. With such yield, process will generally produce very high quality products [Humphrey, 1999].

In the old process, the most of the defects were found during the test phase, however in the newest this was reduced drastically because the early defect reduction was applied. Nevertheless, the value is far from the expected by the TSPi (see Figure 7).

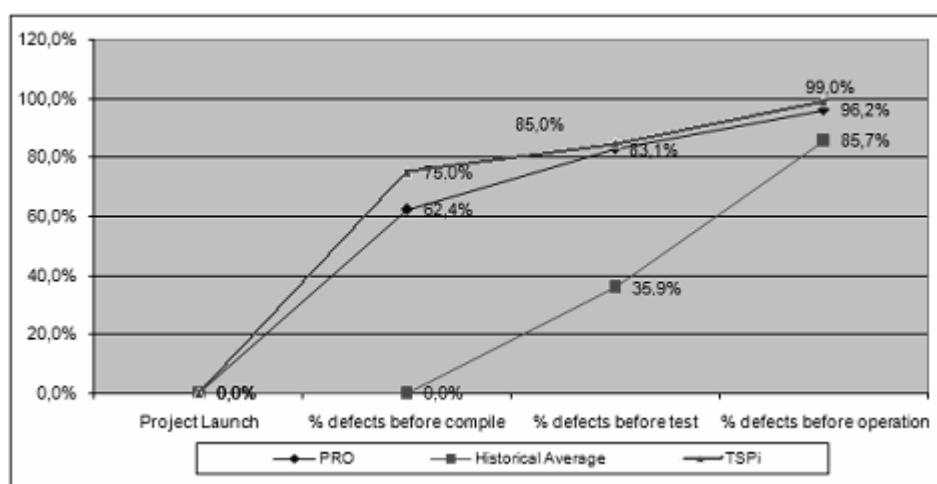


Figure 7 – Quality improvement based in process yield

The Cost of Quality (COQ) is a measure that allows quantifying the size of the quality [Humphrey, 1995].

It has three components, but TSPi only works with two (COQ = Appraisal Costs + Failure Costs):

Appraisal Costs: the cost of evaluating the product to determine its quality level (reviews and inspections).

Failure Costs: the cost of diagnosing a failure, making necessary fixes, and getting back into operation (compilation and test).

Figure 8 shows that the COQ has not changed between the old and the new process (34.7% vs. 35.5%).

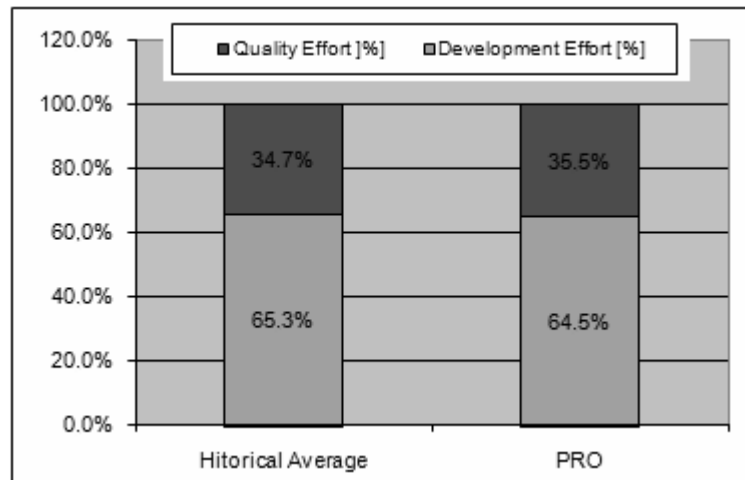


Figure 8 – Cost of Quality

However, if the appraisal costs and failure costs are analyzed in a separated way, the improvement is evident. The new process adopted inspections and formal reviews because it was based on early defect reduction. These new activities allowed increasing the appraisal costs and reducing the failure costs (see Figure 9).

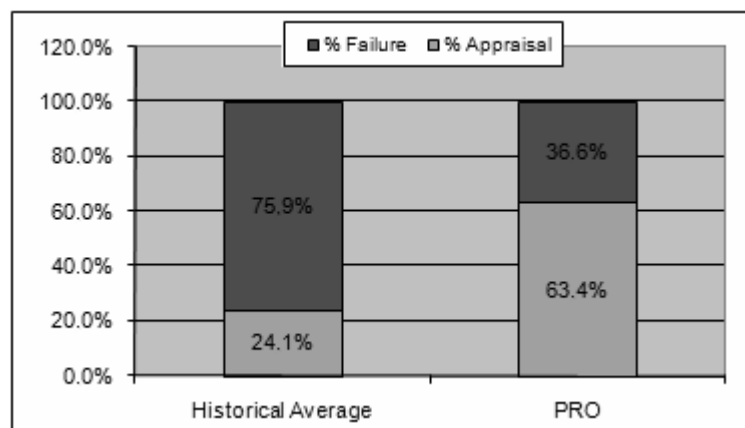


Figure 9 – Appraisal costs vs. Failure costs

Finally, Table 9 summarizes some quality and productivity measures used to verify the improvement.

Table 9 – Goal 3 results

Goal	Historical	PRO	Reduction
Defects before test [%]	35.9%	83.0%	-131.5%
Defects before operation [%]	85.7%	96.2%	-12.3%
Development Effort [%]	65.3%	64.5%	1.2%
Quality Effort [%]	34.7%	35.5%	-2.3%
Appraisal Cost [%]	24.1%	63.4%	-162.8%
Failure Cost [%]	75.9%	36.6%	51.7%
Defects removed [%]	85.7%	96.2%	-12.3%
Defects released [%]	14.3%	3.8%	73.7%

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## Conclusion

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The use of TSPi principles in the new process allowed the accomplishment of project goals based on the following considerations.

1. The team integration, the detailed plan, the change management, the weekly meetings and the earned value method allowed the accomplishment of these goals.
2. Applying the early defect reduction principle, the test productivity has been increased and the re-work decreased.
3. The reviews, inspections and quality plans allowed a quality improvement. The team members understood the test phase as a quality evaluation and not as a defect detection activity.

With an affordable investment in process definition, it has been demonstrated that TSPi is an effective alternative solution for process, quality and productivity improvement in a Very Small enterprise.

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## Bibliography

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- [Standish Group, 2007] Standish group. CHAOS Report, 2007.
- [Serrano, 2006] Serrano, M., Montes, C., Cedillo, K. An Experience on Implementing the CMMI in a Small Organization Using the TSP, 81-92. <http://www.sei.cmu.edu/pub/documents/06.reports/pdf/06sr001.pdf>, 2006.
- [IPRC, 2006] International Process Research Consortium. IPSS White Paper. Improving Process in Small Settings, 2006 <http://www.sei.cmu.edu/iprc/ipss-white-paper-v1-1.pdf>
- [Noopur, 2003] Noopur, D. The Team Software Process in Practice: A Summary of Recent Results. SEI Technical Report CMU/SEI-2003-TR-014, 2003.
- [Humphrey, 2006] Humphrey, W. TSP: Coaching Development Teams. Ed. Addison-Wesley Publishing Company, 2006
- [Humphrey, 1999] Humphrey, W. Introduction to the Team Software Process. Ed. Addison-Wesley Publishing Company, 1999.
- [Humphrey, 1995] Humphrey, W. A Discipline for Software Engineering. Ed. Addison-Wesley Publishing Company, 1995
- [Garcia, 2006] Garcia, S. Graettinger, C., Kost K. Proceedings of the First International Research Workshop for Process Improvement in Small Settings. SEI Special Report CMU/SEI-2006-SR-001, 2005.
- [Garcia, 2005] Garcia, S. Thoughts on Applying CMMI in Small Settings. <http://www.sei.cmu.edu/cmmi/adoption/pdf/garcia-thoughts.pdf>, 2005.
- [Glazer, 2006] Glazer, H. Time to Market vs. Process Discipline. <http://www.sei.cmu.edu/iprc/sepg2006/glazer.pdf>, 2006.
- [Calvo-Manzano, 2008] Calvo-Manzano, J., Gonzalo, C., San Feliu, T., Caballero, E. International Journal "Information Technologies and Knowledge" Vol.2 / 2008, 245-250. <http://www.foibg.com/ijitk/ijitk-vol02/ijitk02-3-p07.pdf>

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